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Canadian Consulting Engineering Awards 2011

Dickson Lake Water System Upgrades

Abbotsford/Mission Water & Sewer Services

City of Abbotsford

MITCHELL INSTALLATIONS LTD. | SCOTT | LEVELTON | OPUS DAYTONKNIGHT | OPUS

CANADIAN CONSULTING ENGINEERING AWARDS 2011
DICKSON LAKE WATER SYSTEM UPGRADES
ABBOTSFORD MISSION WATER & SEWER SERVICES

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SECTION 1.0 – INTRODUCTION

1.1 Official Entry Form

1.3 Project Highlights

Dickson Lake provides approximately 60% of the total drinking water to the City of Abbotsford and the District of Mission (up to 90 MLD). Originally, Dickson Lake was a natural mountain lake in the upper reaches of the Norrish Creek watershed. A dam, an inlet channel and a control structure were built in 1983 to increase the lake's natural storage capacity. A floating pump station together with floating HDPE piping (3 x 450mm, 340 m) were constructed in 1995 to draw additional water from the lake when the water level drops below the elevation of the inlet channel. In 2010, several operational challenges triggered upgrades to the system: increasing summer demands required more volume to be released from the lake; the three HDPE 450 mm diameter pipes were escaping from their anchors causing them to float and become vulnerable to shifting ice. Subsequently, the pipes would crimp and pull away from their connections both at the floating pump station and the discharge.

To increase the system hydraulic capacity and eliminate the pipes displacement from its anchors and connections an optimal design was developed. The design included a single 900 mm ø pipe in the channel, anchored with concrete pipe saddles and rock anchors every 4 meters. The design also called for 3 x 600 mm ø floating HDPE pipes to the floating pump station and fixed flanged connections at the rafts. At the discharge end of the new system, the design specified a 900 mm ø inserted pipe in the existing 1050 mm ø gravity discharge through the dam, which included a branched check valve allowing both gravity inflow and pump flow through the same 1050 mm ø discharge pipe.

The design required careful consideration for the expected movement of the pipe and resulting stresses. Dickson Lake has seasonal variations in water levels of over ten metres. Because the pump station is located on floating rafts it is free to move with the lake level and the piping to shore must allow for this movement. The high mountain lake also sees large seasonal temperature changes. The pipe will see temperature extremes of: submerged within the frozen lake in the winter; and exposed to sunlight in the dried-out channel during certain summer months when the lake level is low.

During the design phase, the expected movement and resulting stresses in the plastic pipe were analyzed. HDPE pipe suppliers were consulted to assist with this analysis of the pipe movement. The design was even modified slightly during construction once the pipe was onsite and it was possible to observe the actual expansion and construction caused by daily temperature fluctuations.

The 900 mm ø HDPE pipe within the channel had a number of unique design features. The concrete pipe saddles at each rock anchor location is sized one pipe size larger than the HDPE pipe in order to resist buoyancy but also allow longitudinal thermal movement of the pipe. The 900 mm ø pipe is inserted 2 meters into the larger 1050 mm ø gravity discharge pipe through the dam. This connection is not fixed and allows for free movement along the length of the pipe. The 2 metre insertion length is sized such that the pipe will not pull out of its host pipe. At the end of the channel where the single 900 mm ø pipe transitions to 3 x 600 mm ø pipes, the pipe header is encased in concrete and contains three flexible ball joints which allow initial rotation of the pipes out to the floating pump station. The large concrete block fixes one end of the 900 mm ø pipe, resists buoyancy and protects the pipe header from large wooden lake debris.

The system at Dickson Lake consists of two basic operations: 1) Gravity flow through the dam's discharge pipes when the lake level is at or above the pipes inlet elevation (or overflow on the spillway when the lake level is at its highest); 2) Pumped flow from the floating pump station when the lake level is below the elevation of the gravity discharge pipes.

Original design concepts included a manually operated gate valve which would be opened and closed to transition back and forth from these two operations. Because the lake level can rise to over 8 meters above the gravity inlet through the dam, access to a manually operated valve would be a challenge. Opus DaytonKnight then determined it would be preferable to include a branched check valve on the 900 mm ø pipe at the discharge box which would automatically transition between the two operations. A Tideflex Checkmate Valve was selected. The valve allows gravity inflow with only 50 mm of back pressure, which is essential in order to maximize the amount of gravity inflow from the lake and avoid unnecessary pumping.

Key to the success of the project was prompt and open communication between all parties involved during construction. The time window available for construction was very short (approximately 1-2 months) and depended on the lake level. The project was fast–tracked and overtime costs were approved once construction started and the schedule was discovered to be of utmost importance to successful completion. The lake level in late summer was unseasonably high when compared to historic levels. Once this was realized, the temporary dam constructed to isolate the channel was built up and raised by 1.5 meters to ensure the project could go ahead. It was essential that service to Abbotsford and Mission's water system was not interrupted during construction. The old 450 mm ø piping was used to construct a temporary by-pass system which utilized the existing floating pump station to pump water from the lake along the bank channel and over the dam spillway so that the channel could be completely isolated. During drilling of the rock anchors a large underground void was discovered below the channel. Levelton, the geotechnical sub-consultant, recommended using a different grouting material in this area to fill this void and solve a problem previously unknown to the City. This work was approved and completed successfully.

The achievement of this project was a hydraulically efficient and sustainable supply of the required 90 ML/day to the Abbotsford and Mission water system. The system upgrades also allow additional drawdown from the lake which extends the duration of the available supply. An anchored pipe intake system resists displacement from its connections due to ice, wave and thermal forces and the seasonal rise and fall of the lake level. An efficient 900 mm ø pipe discharge to gravity with a check valve branch allows both pumped flows during low lake levels and gravity inflow during high lake levels. Construction was completed without any significant residual environmental impacts. The project was completed within a short seasonal time window starting in September, 2010 and finishing by November the same year.

SECTION 2.0 – PROJECT DESCRIPTION

2.1 Project Objectives, Solutions, and Achievements

BACKGROUND

Dickson Lake provides approximately 60% of the total drinking water to the City of Abbotsford and the District of Mission (up to 90 MLD). Originally, Dickson Lake was a natural mountain lake in the upper reaches of the Norrish Creek watershed. A dam, an inlet channel and a control structure were built in 1983 to increase the lake's natural storage capacity. A floating pump station together with floating HDPE piping (3 x 450mm, 340 m) was constructed in 1995 to draw additional water from the lake when the water level drops below the elevation of the inlet channel. In 2010, several operational challenges triggered upgrades to the system: increasing summer demands required more volume to be released from the lake; the three HDPE 450 mm diameter pipes were escaping from their anchors causing them to float and become vulnerable to shifting ice. Subsequently, the pipes would crimp and pull away from their connections both at the floating pump station and the discharge.

Abbotsford Mission Sewer & Water Services retained Opus DaytonKnight to review options for increasing the system hydraulic capacity and eliminating the pipes displacement from its anchors and connections. To deliver this project Opus DaytonKnight retained Levelton Consultants Ltd. to assist in the design and construction supervision of the upgrades. Scott Resources Services Inc. also provided environmental monitoring during construction within the environmentally sensitive waterway and drinking water source.

OBJECTIVES

The objectives were as follows:

- Improve hydraulic efficiency of the lake intake to meet increased summer water demands.
- Prevent the pipe from displacing at its anchors and connections due to movement induced by thermal expansion/contraction, shifting ice and the seasonal rise and fall of the lake level.
- Design a control structure at the inlet through the dam such that:
  1) When the lake level is above the inlet, water will flow by gravity through the dam discharge pipes with minimal headloss, avoiding unnecessary pumping.
  2) During dry periods when the lake level is below the inlet, water will be pumped from the floating pump station at a sufficient rate to meet summer water demands.
- Limit all construction impacts to avoid damage to the environmentally sensitive waterway and drinking water source.

- Supervise construction such that work is completed within a short seasonal time window without interrupting service to Abbotsford and Mission's water supply.

SOLUTIONS

Design options were presented to the Abbotsford Mission Sewer & Water Commission in a series of Design Memoranda, which were studied and considered by Engineering and Operations staff. After a period of feedback and adjustment, Opus DaytonKnight held meetings with City staff to discuss the options and address the issues. Following this review, an optimal option was selected and the project proceeded to detailed design based on a single anchored 900 mm ø HDPE pipe in the channel, 3 x 600 mm ø floating HDPE pipes to the floating pump station, fixed flanged connections at the rafts, a 900 mm ø inserted pipe in the 1050 mm ø gravity discharge through the dam, which included a branched check valve allowing both gravity inflow and pump flow through the same 1050 mm ø discharge pipe.

The design was tendered and Mitchell Installations Ltd. was selected to complete the upgrades. Because of the remote location of the site and the very short seasonal time window available, key to the success of the project was prompt and open communication between the Contractor, OpusDayton Knight and its sub-consultants and the Abbotsford Mission Sewer & Water Engineering and Operation staff. Some of the key issues faced during construction were:

- Tight schedule required limited time between tender award and start of construction - HDPE pipe was selected over steel pipe because of its shorter expected delivery time.
- Rock anchors and concrete work required channel drainage and isolation. Thus, the construction window for work in the channel was very short (approximately 1-2 months) and depended on the lake level. The project was fast–tracked and overtime costs were approved to allow successful completion before the lake level rose above the dam.
- The lake level in late summer was unseasonably high when compared to historic levels. Once this was realized, the temporary dam constructed to isolate the channel was built up and raised by 1.5 meters to ensure the project could go ahead.
- It was essential that service to Abbotsford and Mission's water system was not interrupted during construction. The existing 450 mm ø piping was used to construct a temporary by-pass system which utilized the existing floating pump station to pump water from the lake along the bank channel and over the dam spillway so that the channel could be completely isolated.
- During drilling of the rock anchors a large underground void was discovered below the channel. Levelton recommended using a different grouting material in this area to fill this void and solve a problem previously unknown to the City. This work was approved and completed successfully.

ACHIEVEMENTS

The achievements following from the objectives were:

- Hydraulically efficient and sustainable supply of the required 90 ML/day to the Abbotsford and Mission water system. This also allows additional drawdown from the lake which extends the duration of the available supply.
- Anchored pipe intake system, which resists displacement from its connections due to ice, wave and thermal forces and the seasonal rise and fall of the lake level.
- An efficient 900 mm ø pipe discharge to gravity with a check valve branch which allows both pumped flows during low lake levels and gravity inflow during high lake levels.
- Construction completed without any significant residual environmental impacts.
- Project completed within short seasonal time window starting in September, 2010 and finishing by November the same year.

2.2 Technical Excellence and Innovation

HDPE Pipe Design – The design required careful consideration for the expected movement of the pipe and resulting stresses. Dickson Lake has seasonal variations in water levels of over ten metres. Because the pump station is located on floating rafts it is free to move with the lake level and the piping to shore must allow for this movement. The high mountain lake also sees large seasonal temperature changes. The pipe will see temperature extremes of: submerged within the frozen lake in the winter; and exposed to sunlight in the dried-out channel during certain summer months when the lake level is low.

During the design phase, the expected movement and resulting stresses in the plastic pipe were analyzed. HDPE pipe suppliers were consulted to assist with this analysis of the pipe movement. The design was even modified slightly during construction once the pipe was onsite and it was possible to observe the actual movement caused by daily temperature fluctuations. Key aspects of the design are as follows:

- Concrete pipe saddle at each rock anchor location sized one pipe size larger than the HDPE pipe in order to resist buoyancy but also allow longitudinal thermal movement of the pipe.
- The 900 mm ø pipe is inserted 2 meters into the larger 1050 mm ø gravity discharge pipe through the dam. This connection is not fixed and allows for free movement along the length of the pipe. The 2 meter insertion length is sized such that the pipe will not pull out of its host pipe.
- At the end of the channel where the single 900 mm ø pipe transitions to 3 x 600 mm ø pipes, the pipe header is encased in concrete and contains three flexible ball joints which allow initial rotation of the pipes out to the floating pump station. The large concrete block fixes one end of the 900 mm ø pipe, resists buoyancy and protects the pipe header from large wooden lake debris.

Check Valve at the Gravity Discharge – The system at Dickson Lake consists of two basic operations: 1) Gravity flow through the dam's discharge pipes when the lake level is at or above the pipes inlet elevation (or overflow on the spillway when the lake level is at its highest); 2) Pumped flow from the floating pump station when the lake level is below the elevation of the gravity discharge pipes.

Original design concepts included a manually operated gate valve which would be opened and closed to transition back and forth from these two operations. Because the lake level can rise to over 8 meters above the gravity inlet through the dam, access to a manually operated valve would be a challenge. Opus DaytonKnight then determined it would be preferable to include a branched check valve on the 900 mm ø pipe at the discharge box which would automatically transition between the two operations. A Tideflex Checkmate Valve was selected. The valve allows gravity inflow with only 50 mm of back pressure, which is essential in order to maximize the amount of gravity inflow from the lake and avoid unnecessary pumping.

2.3 Environmental, Economic and Social Sustainability and Aesthetic Aspects

Environmental Sustainability **–** The construction of the Dickson Lake Upgrades did not result in residual environmental impacts, as a result of design consideration and supervision during construction including:

- Single above-grade pipeline in the inlet channel without requiring disruptive trench-excavation within the waterway.
- Optimized sustainable capacity of the lake's gravity water supply, reducing reliance on the pumped system and subsequently reducing diesel consumption of the generator used to power the pumps.
- Requirement in the Construction Contract that all equipment used for work within the channel to use vegetable based drilling and hydraulic fluids to avoid contamination of the waterway.
- Fish salvaging operation conducted by Scott Resources Services (environmental consultant) in the channel once the temporary dam was constructed and the channel was isolated.
- Coordination of the in-channel works such that work was only allowed during hydraulic isolation and drainage of the channel preventing contaminated run-off to the downstream creek from uncured concrete and grout mixtures used for the rock anchors, pipe saddles, discharge box and pipe header block.
- Open communication between the prime consultant, environmental monitor, contractor and client to mitigate any potential impacts and address any unforeseen concerns promptly throughout the construction period.

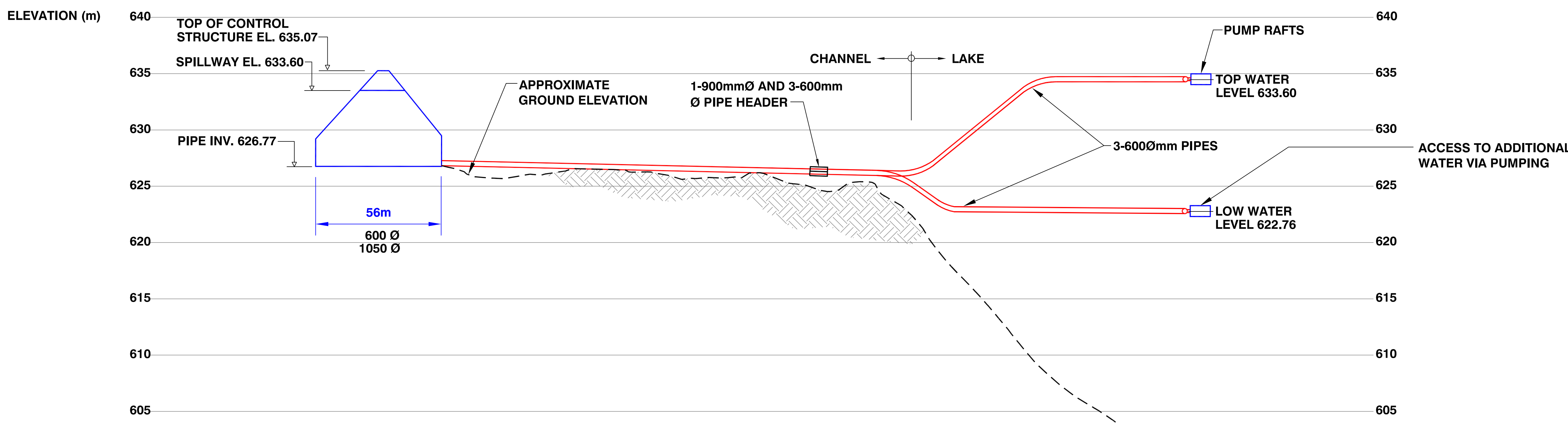
Economic Sustainability **–** The optimization of the lake's gravity water supply and resulting reduction in the pumped system's fuel consumption reduces future operating costs to the Abbotsford Mission Sewer & Water Services. The 900 mm ø check valve at the discharge box provides automation of the change from gravity inflows to pumped flows without the need for manual operation, reducing labour costs over time. The system's increased reliability will reduce maintenance costs.

Social Sustainability **–** The completion of the construction during a short seasonal time window while maintaining a fully functional bypass pumping system for the entire construction period ensured no service interruption to the public's water supply. Given the increasing water demands in the City of Abbotsford and District of Mission, the upgrades at Dickson Lake secure a sustainable supply of water with a safe, reliable and robust water system.

Aesthetic Aspects **–** The remote location of this project minimizes concerns for the aesthetic aspects of the new infrastructure. Only during low lake levels is the new piping visible and even then only the 900 mm ø pipe in the channel is exposed. Selection of the single 900 mm ø pipe in the channel as opposed to three pipes minimizes the visual impact to the surrounding area when the lake level is low and allows the pipe to integrate into the natural grade of the channel.

SECTION 3.0 – PROJECT PHOTOS AND SKETCHES

AERIAL VIEW
N.T.S.



TYPICAL SECTION
SCALE: HORIZ. 1:2000 VERT. 1:400

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ABBOTSFORD MISSION SEWER AND WATER SERVICES
DICKSON LAKE UPGRADES

FIGURE 1

FILE: L:\MARKETING\Awards Submissions\CEBC\2011\Dickson Lake\ref\DICKSON LAKE FIGURE 1.dwg Tab FIGURE 1 11-01-17 asandhu

Photo 1: Channel and lake water level at start of construction, September 2010

Photo 2: Construction of temporary lock-block dam to allow for work within the channel. Temporary bypass piping shown on far shore.

Photo 3: Drilling Rock Anchors in Channel: All equipment within channel used vegetable based drilling and hydraulic fluids to avoid contamination of waterway.

Photo 4: Installation of 900 mm ø HDPE pipe in dewatered channel after construction of temporary dam and rock anchor drilling.

Photo 5: 900 mm ø HDPE pipe installed in channel with concrete saddle supports and rock anchors to prevent pipe flotation while allowing thermal expansion/contraction of the HDPE pipe.

Photo 6: Pipe Header Block installed at the end of the channel with flexible ball joints allowing initial rotation of the 3 - 600 mm ø pipes out to the floating pump station.

Photo 7: 900 mm ø Piping at Discharge Box: Check valve to be installed on Wye branch allowing gravity inflow during high water levels and pumped flow during low water levels.

Photo 8: Channel and lake water level after removal of the temporary dam, towards the end of construction, November 2010.